Silicon Photonics Circuits with Programmable Memory Functionality

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Silicon photonics circuits are playing more and more important role in optical communication and interconnect fields [1,2]. Many silicon CMOS technique compatible photonics integrated devices are reported [3,4]. Most of those silicon components are based on optical waveguide. But conventional integrated optical waveguide is without memory feature. One hand, which makes us in trying to change the refractive index of the optical waveguide, must continually support energy to maintain the state of the waveguide, such as optical switch and modulators. And other hands, memory functional PIC into computer memory system, will solve van Neumann bottleneck issue.

In this presentation, we propose and experimentally demonstrate two solutions. First one is a non-volatile optical waveguide structure. The schematic diagram, SEM pictures of the waveguide section are illustrated in Fig. 1. For checking the memory functionality, we made a microring resonator by memory optical waveguide. By measuring the optical spectrum, the memory properties of mantain and retention are proved. And using different pulse voltage to drive electrons will cause multi-level state in the optical spectrum. Another solution is using memristor device to control the optical waveguide property. The schematic diagram and SEM and TEM pictures are showing in Fig. 2. The SONOS as the memristor, series connect with P-N junction optical waveguide. The memristor situation determines the series current, thus change the optical waveguide states. Similarly, we fabricate a microring resonator with P-N junction waveguide. SONOS controlled current to modify the microring resonator's oscillation wavelength. From optical spectrum, we will know the SONOS status. We believe those kind of memory functionality silicon PIC should useful for green photonic circuits. In memory input/output interface, will enhance the memory cell sensing speed ~1000 times.

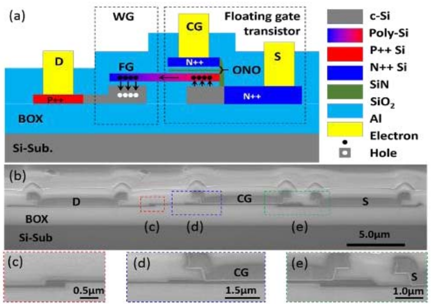

Fig. 1 CMOS technology fabricated waveguide structure. (a) schematic diagram of non-volatile waveguide structure. (b) SEM picture of waveguide cross section. (c), (d) and (e) are zooming in SEM.

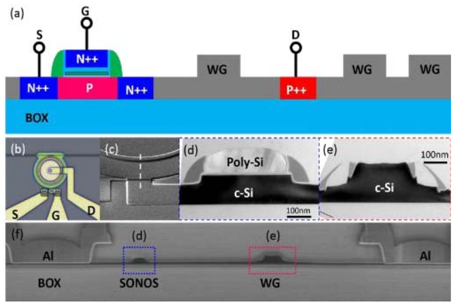

Fig. 2 Memristor and microring resonator integrated circuits. (a) Schematic diagram. (b) OM picture. (c) SEM picture. (d) TEM of SONOS section. (e) TEM of waveguide cross section. (f) Cross section in white dished line in (c).

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Example References

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